RADIAL TYPE HYDRAULIC MACHINE

Technical Field

The present invention relates to a radial type hydraulic

5   machine which prevents imbalance in a radial direction that

works on a pintle in the hydraulic machine in a radial type

piston pump, a radial type piston motor, a radial type

alternating pump or the like as the radial type hydraulic

machine.

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Background Art

In conventional radial type hydraulic machines, a Hele

Shaw type radial piston pump with both ends of a cylinder block

15   rotatably supported (Refer especially to FIG. 7 in "Yasuo KITA:

HYDRAULIC AND PNEUMATIC ART, Vol. 40, No. 13, PP.

6-11, 2001", for example).   A radial type pump which prevents

imbalance in a radial direction of hydraulic pressure acting on a

pintle is known (Refer especially to lines 66 to 67 in column 3,

20   lines 25 to 40 in column 6, and FIG. 1 and FIG. 3 in the U. S.

Patent No. 3087473, for example).

The above-described Hele Shaw type radial piston pump

will be explained with use of FIG. 8.   A low pressure port 33

and a high pressure port 32 are formed in a pintle 31 which is

25   supported at a motor case 30 to be incapable of rotating, and

pressure oil is sucked from the low pressure port 33 into a cylinder 36 formed inside a cylinder block 35 rotationally driven by a rotating shaft 34. The cylinder block 35 is supported by the motor case 30 at both ends via bearings 37,

5   and by rotation of the cylinder block 35, a slipper 40 supported at a tip end portion of a piston 38 via a pin 39 is slid along an inner circumference surface of a floating ring 41. In this situation, the pressure oil sucked from the low pressure port 33 is pressurized to be pressure oil at high pressure, which is

10 discharged outside the pintle 31 through the high pressure port 32. The discharge amount of the high pressure port 32 can be adjusted by moving the floating ring 41 in a direction orthogonal to the paper surface of FIG. 8.

In this Hele Shaw type radial piston pump, the cylinder

15 block 35 is supported by the motor case 30 via the bearings 37, and the pintle 31 is supported by the motor case 30, therefore making it possible to keep a predetermined clearance between the pintle 31 and the cylinder block 35 in structure, namely keep a clearance for fluid lubrication.

20 However, the pintle 31 is pressed against the low pressure port 33 side by the pressure oil of the high pressure port 32 formed in the pintle 31, and the pintle 31 causes imbalance in a radial direction. The imbalance in the radial direction makes the fluid lubrication as the lubrication at the

25 side of the low pressure port 33 boundary lubrication or metal

contact, thus causing a twist between the pintle 31 and an inner circumference surface of the cylinder block 35.   Occurrence of the twist becomes conspicuous especially at low speed rotation and at high pressure.   This twist increases abrasion

5   between the pintle 31 and the cylinder block 35.

As a result, oil leakage increases, and pressure oil of the high pressure port 32 flows out to a drain channel (not shown) or the like formed in the pintle 31, or flows into the low pressure port 33, thus making it impossible to take out high

10   pressure oil from the high pressure port 32.   Consequently, the pump operation cannot be performed, and a life as the pump is shortened.

As a radial type pump which is constituted so that imbalance in the radial direction is not caused to the pintle by

15   the pressure oil of the high pressure port in the pintle, the same kind of radial type pump is disclosed in the U. S. Patent No. 3087473.   This radial type pump will be explained with use of FIG. 9 and FIG. 10.

FIG. 9 shows a section of the radial type pump, and FIG.

20   10 shows a section taken along the line 10-10 in FIG. 9.   A cylinder block 52 is supported at a pump case 50 via bearings 51 and fitted to a rotating input shaft 53.   The pintle 55 is provided slidaby in the cylinder block 52 and the pump case 50. In the pintle 55, formed are a high pressure port 56, and a low

25   pressure port 57, and cancel ports 58 and 59 for preventing

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imbalance in the radial direction by high pressure port 56, which are formed at regions of both side portions of the low pressure port 57, and two of each of which are formed in a circumferential direction (see FIG. 10). The pressure oil of

5 the high pressure port 56 is supplied to the cancel ports 58 via a passage 60 formed inside the pintle 55, and the pressure oil of the high pressure port 56 is supplied to the cancel port 59 via a passage 61 formed inside the pintle 55.

A known cylinder 64, a piston 65, a piston shoe 66 and

10 the like are constituted in a cylinder bore section 63 of the cylinder block 52, which constitute a pump function with an eccentric cam ring 67. A direction of the force, which the pintle 55 presses to the side of the low pressure port 57 by the pressure oil of the high pressure port 56, and a direction of a

15 resultant force of the pressing forces of the cancel ports 58 and 59 two of each of which are formed at two spots respectively are balanced. Consequently, a balance in the radial direction of the pintle 55 is kept.

However, in the aforementioned radial type pump, one

20 end side of the cylinder block 52 is supported at one side by the bearing 51, and the other end side is supported by the pintle 55. Due to this, load forces in the radial direction occurring between the eccentric cam ring 67, and the piston 65 of the cylinder bore section 63 and the piston shoe 66 are supported by

25 the bearing 51 and the pintle 55. The forces in the radial

direction bend a free end portion of the cylinder block 52 for the cylinder block 52 supported at one side with the bearing 51 as a fulcrum.

As a result, a twist is caused between the cylinder block

5　52 and the pintle 55. The twist occurring between the cylinder block 52 and the pintle 55 increases abrasion between the cylinder block 52 and the pintle 55, enlarges a clearance between the cylinder block 52 and the pintle 55, and as a result, oil leakage, which is the pressure oil of the high pressure port

10　56 flowing out to a drain as it is, or flowing into the low pressure port 57, increases. Consequently, the life as the pump is shortened.

As shown in FIG. 10, each of the cancel ports 58 and 59 has its ports formed at two spots in the radial direction of the

15　pintle 55. Therefore, it is difficult to form the cancel ports to keep the balance of the force acting on each of the cancel ports 58 and 59 by the placement positions of the ports at two spots in each of the cancel ports 58 and 59. It is especially difficult to set the vector direction of the totaled force of the pressing

20　forces from the total of four ports of the cancel ports 58 and 59 and the vector direction of the force acting from the high pressure port 56 on the same straight line. When both the vector directions are not on the same straight line, the force acts on the pintle 55 as rotation moment, which becomes the

25　cause of occurrence of the twist between the cylinder block 52

and the pintle 55.

Consequently, in the conventional pump, imbalance in the radial direction of the pintle is caused by the pressure oil acting on the pintle, and the cylinder block is bent by the pressing forces acting between the eccentric cam ring, and the piston and the piston shoe, whereby a twist occurs between the cylinder block and the pintle. Even if there is no difficulty in adopting the aforementioned constitution which does not cause the imbalance in the radial direction to the pintle by the pressure oil of the high pressure port in the pintle in the support constitution of the cylinder block in the Hele Shaw type radial piston pump, the following problem still exists as described above.

Since each of the cancel ports 58 and 59 has the ports formed at two spots in the circumferential direction of the pintle, it is difficult to form the respective ports at the placement positions of the ports at two spots in each of the cancel ports 58 and 59 so that the force acting on each of the cancel ports can be balanced. It is especially difficult to set the vector direction of the totaled force of the pressing forces from the total of four spots of the cancel ports 58 and 59, and the vector direction of the force acting from the high pressure port on the same straight line. Since an end portion of the cylinder block 35 and the rotating shaft 34 are constituted separately in a Hele shaw type radial piston motor, the length in

a shaft direction of the piston motor becomes large, and it is
difficult to make the piston motor compact.

Summary of the Invention

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The present invention has its object to solve the
above-described conventional problem and provide a radial type
hydraulic machine which prevents a cylinder block from being
bent by a pressing force acting between an eccentric cam ring,
10   and a piston and a piston shoe, and which does not cause
imbalance in a radial direction of a pintle by pressure oil acting
on the pintle.

In order to attain the above-described object, a radial
type hydraulic machine according to the present invention
15   comprises: a pintle, which is supported at a casing of a radial
type hydraulic machine to be incapable of rotating, and has a
high pressure port and a low pressure port, and port passages
communicating with the high pressure port and the low pressure
port, respectively; a cylinder block relatively rotatable with
20   respect to the pintle; and cylinder bore section, which
communicates with the high pressure port and the low pressure
port by switching between them at the time of rotation of the
cylinder block, and includes a plurality of cylinders; and the
cylinder block is supported via bearings at both sides with the
25   cylinder bore section between them to be rotatable with respect

to the casing, and one end of the cylinder block is connected to a rotating shaft of the radial type hydraulic machine; and cancel ports for balancing with a radial force from the high pressure port, which acts on the pintle, are formed at regions of the

5   pintle, to which the high pressure port opposes, and pressure oil of the high pressure port is introduced into the cancel ports.

According to the above constitution, the rotating shaft is connected to the one end of the cylinder block, and the cylinder block is supported at the casing at both ends via the bearings at

10   both sides with the cylinder bore section between them.   Due to this, the load force acting on the cylinder bore section at the time of operation of the radial type hydraulic machine, namely, the pressing force, which acts between the eccentric cam ring, and the piston and the piston shoe provided inside the cylinder

15   bore, can be balanced at the bearings and reliably supported.

In the cylinder block described in the above-described Hele shaw type radial piston pump, both end portions supported by bearings are in a hollow shape and fitted to the rotating shaft. On the other hand, the present invention has the constitution in

20   which the one end portion of the cylinder block is connected to the rotating shaft, and therefore the one end portion of the cylinder block supported with the bearing can be made solid. Due to this, the rigidity of the cylinder block end portion, which is applied to the bearing portion, can be enhanced, so

25   that the bending amount of the cylinder block can be reduced to

be small, thus making it possible to prevent the occurrence of a twist between the cylinder block and the pintle reliably as compared with the aforementioned Hele Shaw type radial piston pump.

5　　　　The cancel ports for balancing with the radial force from the high pressure port acting on the pintle are formed at the regions to which the high pressure port opposes in the pintle, whereby formation of the cancel port is facilitated as compared with that in the U. S. Patent No. 3087473.　In addition, the

10　cancel ports are formed at the regions to which the high pressure port opposes, and thereby balance with the radial force from the high pressure port can be easily kept.

The same pressure oil as that of the high pressure port can be introduced into the cancel port, or the pressure oil

15　corresponding to the port area of the cancel ports can be additionally introduced correspondingly to the port area of the high pressure port and the pressure oil of the high pressure port. The port area will be explained in the embodiment.

As described above, according to the present invention

20　in application, balance with the radial force acting on the pintle by the high pressure port can be kept, in addition to that the load force acting on the cylinder bore section can be balanced with the bearings and reliably supported.　Consequently, the hydraulic machine can be smoothly operated for a long period

25　of time without causing a twist between the cylinder block and

the pintle.

In the radial type hydraulic machine, the cancel ports may be formed at both side regions of the low pressure port along a circumferential direction of the pintle each in a shape of a line of a narrow slit. According to this constitution, the cancel ports can be formed at the pintle without changing the length in the axial direction of the pintle.

In the radial type hydraulic machine, the pressure oil of the high pressure port is introduced into the cancel ports, and each of hydrostatic bearing capacities on a port area by the cancel ports, and a port area by the high pressure port may be made equal. According to this constitution, the radial force from the high pressure port can be balanced by the cancel ports with stability.

In addition, each of the hydrostatic bearing capacities on the port area, which is obtained with the width in the axial direction of the pintle in the cancel ports in a slit shape provided at the both side regions of the low pressure port and the width of the land portions adjacent to the cancel ports, and on the port area, which is obtained with the width of the high pressure port in the axial direction of the pintle and the width of the land portions adjacent to the high pressure port, is made equal. Due to this, the radial force from the high pressure port can be balanced with the cancel ports. Here, the land portion is the portion where the port is not formed on the outer

circumference surface of the pintle, and the width of the land
portion is assumed to be the length from the cancel port with
which one land portion is in contact to the low pressure port.
Especially by forming a pair of cancel ports formed at the both
side regions of the low pressure port at the symmetrical
positions with respect to the low pressure port, the radial force
from the high pressure port is made more uniform to the bearing
and balanced in the stable state.

In the radial type hydraulic machine, ports for low
pressure each in a shape of a line of a narrow slit may be formed
at both side regions of the high pressure port along the
circumferential direction of the pintle, which are the regions of
the pintle to which the low pressure port opposes, and pressure
oil of the low pressure port may be introduced into the ports for
low pressure.   According to this constitution, the radial force
to the pintle by the low pressure port can be balanced with the
ports for low pressure, and the port area of the high pressure
port can be reliably defined by the width of the land portions
between the ports for low pressure and the high pressure port.

The cancel ports can be always placed at the regions of
the pintle, which oppose to the high pressure port, in which
direction the cylinder block may rotate, for the pintles in a
hydraulic motor, an alternating pump, a pump / motor as the
radial type hydraulic machine, and the ports for low pressure
can be also placed at the regions of the pintle to which the low

pressure port opposes.

Due to this, the load on the bearings for supporting the cylinder block can be reduced. Since the load on the bearings can be reduced in the radial type hydraulic machine of a tandem type or the like provided with a plurality of rows of cylinders, the bearing for the type with one cylinder row can be used without using the bearing for a plurality of cylinder rows, thus making it possible to reduce the constitution of the bearing portion in size.

In the radial type hydraulic machine, each of hydrostatic bearing capacities on a port area by the ports for low pressure and a port area by the low pressure port may be made equal. According to this constitution, the radial force to the pintle by the low pressure port can be reliably balanced with the ports for low pressure. Consequently, the load applied onto the bearings of the cylinder block can be further reduced.

The radial type hydraulic machine is a radial type hydraulic machine having a plurality of rows of the cylinders in the cylinder bore section, and the cancel ports may be formed at regions to which the high pressure port in each row opposes in the pintle. According to this constitution, the force in the radial direction to the pintle by the high pressure port can be balanced in each row.

In the radial type hydraulic machine, ports for low pressure each in a shape of a line of a narrow slit may be formed

at both side regions of the high pressure port along the circumferential direction of the pintle in the each row, which are the regions of the pintle to which the low pressure port in the each row opposes, each of hydrostatic bearing capacities on

5   a port area by the ports for low pressure and a port area by the low pressure port corresponding to the ports for low pressure may be made equal, and pressure oil of the low pressure port is introduced into each of the ports for low pressure.

According to the above constitution, the ports for low

10   pressure are formed at the regions of the pintle to which the low pressure port opposes in each row of a plurality of rows, and the pressure oil of the low pressure port is introduced into the ports for low pressure. Due to this, the radial force to the pintle by the low pressure port can be balanced with the ports for low

15   pressure, and the port area of the high pressure port can be reliably defined by the width of the land portions between the ports for low pressure and the high pressure port.

In a hydraulic motor, an alternating pump, and a pump / motor as the radial type hydraulic machine constituted with a

20   plurality of rows, for each pintle of them, the cancel ports can be always placed at the regions of the pintle opposing to the high pressure port, in which direction the cylinder block may be rotated. Due to this, the ports for low pressure can be also placed at the regions of the pintle, to which the low pressure

25   port opposes. In addition, the load on the bearings supporting

the cylinder block can be reduced, and a compact bearing for a type with one cylinder row can be used without using the bearing for a plurality of cylinder rows, thus making it possible to reduce the constitution of the bearing portion in size.

5　　　　In the radial type hydraulic machine, the high pressure port in each row may be evenly placed at the position in the circumferential direction of the pintle.　According to this constitution, the pressure from the high pressure port can be balanced in the circumferential direction of the pintle.　By

10　adjusting the placement position of the high pressure port in each row with respect to the axial direction of the pintle, the pressure by the high pressure port in the axial direction of the pintle can be balanced.

15　　　　　　　　　**Brief Description of the Drawings**

FIG. 1 is a sectional side view of a radial type variable displacement pump according to an embodiment of the present invention;

20　　　　FIG. 2 is a sectional side view of a radial type variable displacement pump of a tandem type according to the embodiment;

FIG. 3 is an outline view of a pintle according to the embodiment;

25　　　　FIG. 4 is a sectional view of the pintle according to the

embodiment;

FIG. 5 is a surface development of the pintle according to the embodiment;

FIG. 6A and FIG. 6B are explanatory views showing

5   pressure states in ports,

FIG. 6A shows a pressure state when taken along the cutting-plane line 6A-6A in FIG. 5, and

FIG. 6B shows a pressure state when taken along the cutting-plane line 6B-6B in FIG. 5;

10   FIG. 7A to FIG. 7D are sectional views in respective sections in FIG. 3,

FIG. 7A shows a section along the line 7A-7A in FIG. 3,

FIG. 7B shows a section along the line 7B-7B in FIG. 3,

FIG. 7C shows a section along the line 7C-7C in FIG. 3, and

15   FIG. 7D shows a section along the line 7D-7D in FIG. 3;

FIG. 8 is a sectional side view of a Hele Shaw type radial piston pump in a prior art;

FIG. 9 is a sectional view of a radial type pump in a prior art; and

20   FIG. 10 is a sectional view along the line 10-10 in FIG. 9.

Best Mode for Carrying out the Invention

25   A preferred embodiment of the present invention will be

concretely explained below based on the attached drawings.

The present invention can be effectively applied to a hydraulic machine including a pintle in which a high pressure port and a low pressure port are formed, and a constitution in which a

5   cylinder block is supported to be relatively rotatable with respect to the pintle, and a cylinder bore section having a plurality of cylinders communicates with the high pressure port and the low pressure port to be switchable between them, in a radial type hydraulic machine such as, for example, a radial

10   type pump, a radial type motor, or a radial type alternating pump.   As the hydraulic machine, a fixed displacement type and variable displacement type hydraulic machines are included.

The explanation will be made with use of a radial type

15   variable displacement pump as the embodiment of the present invention.   However, the radial type hydraulic machine of the present invention in application is not limited to the radial type variable displacement pump, but it can be applied to any radial type hydraulic machine such as a radial type motor or a radial

20   type alternating pump which is a radial type irrespective of a fixed displacement type or a variable displacement type, or a single row type or a double row type in terms of a cylinder row.

FIG. 1 shows a sectional side view of the radial type variable displacement pump.   FIG. 2 shows a sectional side

25   view of a radial type variable displacement pump of a tandem

type.   As the tandem type, the type in which a plurality of cylinders provided in a radial direction of a cylinder bore section constituting a piston section are provided in two rows is shown.   Here, a constitution and operation of a radial type variable displacement pump with one cylinder row will be explained first with use of FIG. 1, and constitutions of cancel ports and ports for low pressure will be explained next with use of FIG. 2 to FIG. 7D.

As shown in FIG. 1, the radial type variable pump supports a pintle 3 to be incapable of rotating with respect to a casing 1 and movable a very small amount in an axial direction of the pintle 3, and the casing 1 supports a cylinder block 4 to be relatively rotatable with respect to the pintle 3.   One end portion of the cylinder block 4 is connected to a rotating shaft 5, and at both end portions of a cylinder bore section 6, the cylinder block 4 is supported at the casing 1 via bearings 7. The cylinder block 4 can be constituted integrally with the rotating shaft 5.   The pintle 3 is supported to be movable by a very small amount in the axial direction, but it can be fixed to be incapable of rotating with respect to the casing 1.   A seal 8 such as a floating seal is provided between the rotating shaft 5 and the casing 1 to seal an inside of the casing 1 hermetically.

A plurality of cylinders 10 are formed in a radius direction of the cylinder bore section 6, a piston 11 is slidably provided in each of the cylinders 10, and a piston shoe 12 is

rotatably supported at a tip end of the piston 11. The piston shoe 12 slides along an inner circumference surface of an eccentric cam ring 2, which is slidably supported in the casing 1, and the piston shoe is positioned by a piston ring 13 so as to be

5   in sliding contact with the inner circumference surface of the eccentric cam ring 2. A discharge capacity of the pump can be changed by sliding the eccentric cam ring. 2.

A high pressure port 15 and a low pressure port 16 communicate with port passages 17 and 18 formed inside the

10   pintle 3, respectively, and the respective port passages 17 and 18 are connected to conduit lines (not shown) outside the casing 1 via ports 23 and 24. Cancel ports 20a and 20b are formed at regions at both side portions of the low pressure port 16, which are regions of the pintle 3 to which the high pressure port 15

15   opposes, and they are constituted so that the pressure oil of the high pressure port 15 can be introduced into them via cancel passages 21a and 21b. Drain channels 22 are formed at an outer side portion of the cancel ports 20a and 20b. Placement relationship and the like of the cancel ports 20a and 20b and the

20   low pressure port 16 will be described later with use of FIG. 2 to FIG. 7D.

Next, an operation of the radial type variable pump will be explained with use of FIG. 1. By rotating the cylinder block 4 by rotating the rotating shaft 5, the pressure oil, which

25   is introduced from the passage connected to the outside conduit

line and provided inside the casing 1 via the port 24 through the port passage 18, is sucked into the cylinder 10 from the low pressure port 16.   The sucked pressure oil is compressed by the piston 11 performing a compression operation from a

5   suction operation based on an eccentricity amount of a center of the inner circumference surface of the eccentric cam ring 2 and a center of rotation of the cylinder block, and is discharged from the piston 11 as the pressure oil at high pressure.

The pressure oil, which is compressed to be the high

10   pressure oil, is supplied to the conduit line and the like outside the casing from the high pressure port 15 via the port passage 17, and the port 23.   In this situation, part of the pressure oil from the high pressure port 15 is introduced into the cancel ports 20a and 20b, which are formed at the regions of both side

15   portions of the low pressure port 16, through the cancel passages 21a and 21b provided inside the pintle 3, and acts on the pintle 3 as the force which is balanced with the pressing force to the pintle 3 by the high pressure port 15.

As for the placement position of the cylinder bore

20   section 6, the eccentric cam ring 2, the high pressure port 15, the low pressure port 16 and the cancel ports 20a and 20b, they can be placed at a center portion of the bearings 7 for supporting the cylinder block 4, and they can be placed at the position symmetrical with respect to a center line between both

25   the bearings 7.   Consequently, the force in the radial direction

of the pintle 3 by the pressure oil can be balanced in a stable state without being biased.   The bearings 7 for supporting the cylinder block 4 can support a load force acting between the eccentric cam ring 2, and the piston shoe 12 and the piston 11,

5   which acts on the cylinder bore section 6, in a stationarily and dynamically stabilized state.   Since the cylinder bore section 6 is especially placed at the center portion of both the bearings 7, both the bearings 7 can evenly support the load force acting on the cylinder bore section 6.

10   A constitution of the cancel ports and the like will be explained next with use of the radial type variable displacement pump of the tandem type with use of FIG. 2 to FIG. 5.   The radial type variable displacement pump of the tandem type shown in FIG. 2 differs from the radial type of variable

15   displacement pump in FIG. 1 in the point in which the eccentric cam rings 2 and 2' and the cylinder rows are provided in two rows.   However, the basic constitution of the pump operation and the like by the eccentric cam rings 2 and 2' and the pistons 11 and 11' is the same as in the radial type variable

20   displacement pump in FIG. 1, and the same operations are provided.   Thus, the same reference numerals and symbols, or the same reference numerals and symbols with "'" being given are used for the components providing the same operations, whereby the explanation of the constitutions and the operations

25   will be omitted.

In FIG. 2, a first high pressure port 15 and a second high pressure port 15' are placed to be displaced in an axial direction of the pintle 3, and are formed at the positions symmetrical with respect to a center axis line of the pintle 3 at 180 degrees in the circumferential direction. A first eccentric cam ring 2 and a second eccentric cam ring 2' have their eccentricity directions arranged in the opposite directions from each other. Namely, the first high pressure port 15 and the second high pressure port 15' are arranged to be evenly placed in the circumferential direction of the pintle 3, and the load forces acting on the cylinder bore section 6 from the first row and the second row of the cylinder rows act on the opposite directions respectively, and can be balanced. Since the cylinder bore section 6 is placed at the center portion of both the bearings 7, both the bearings 7 can equally support the load force acting on the cylinder bore section 6.

FIG. 3 shows an outline view of the pintle 3, FIG. 4 shows a sectional view of the pintle 3, and FIG. 5 shows a surface development of the pintle 3. FIG. 7A to FIG. 7D show respective sectional views in FIG. 3. As shown in an upper side of FIG. 5, at a semicircle part side on the circumferential surface of the pintle 3, which faces the cylinder bore section 6, the drain channel 22, the cancel port 20a in a shape of a line of a narrow slit, the low pressure port 16, the cancel port 20b in a shape of a line of a narrow slit, a port 25a' for low pressure in a

shape of a line of a narrow slit, the high pressure port 15', a port 25b' for low pressure in a shape of a line of a narrow slit, and the drain channel 22 are formed along the axial direction from the left to the right.

As shown in the lower sides of FIG. 3 and FIG. 5, at a remaining semicircle part of the circumferential surface of the pintle, the drain channel 22, a port 25a for low pressure in a shape of a line of a narrow slit, a cancel port 20a' in a shape of a line of a narrow slit, a low pressure port 16', a cancel port 20b' in a shape of a line of a narrow slit, and the drain channel 22 are formed along the axial direction from the left to the right.

Namely, the ports 25a and 25b each formed in the shape of a line of the narrow slit are formed at width positions of regions of both side portions of the high pressure ports 15, and the ports 25a' and 25b' each formed in the shape of a line of the narrow slit are formed at regions of both side portions of the high pressure port 15'. The cancel ports 20a and 20b each formed in a shape of a line of the narrow slit are formed at positions of equal width of regions of both side portions of the low pressure port 16, and the cancel ports 20a' and 20b' each formed in a shape of a line of the narrow slit are formed at positions of equal width of regions of both side portions of the low pressure port 16'. The drain channels 22 are formed at the side of the both side end portions of these ports,

respectively. The pressure oil of the opposing low pressure ports 16 and 16' is introduced into the ports 25a, 25b, 25a' and 25b' for low pressure, respectively, but the port passages communicating with the respective low pressure ports 16 and

5 16' are formed in common, and the pressure oil at the same pressure can be introduced into each of the ports 25a, 25b, 25a' and 25b' for low pressure.

Grooves each in a projected form are formed at tip ends of the high pressure ports 15 and 15' and the low pressure ports

10 16 and 16', namely, at the tip ends in the circumferential direction of the pintle 3. The grooves in the projected form can suppress the pressure variation of the pressure oil sucked into the cylinders 10 and 10' from the low pressure ports 16 and 16' and the pressure variation at the time when the pressure oil

15 at high pressure discharged from the cylinders 10 and 10' flows into the high pressure ports 15 and 15'.

As shown in FIG. 7A to FIG. 7D, the cancel ports 20a, 20b, 20a' and 20b' are connected to the high pressure ports 15 and 15', and the ports 25a, 25b, 25a' and 25b' for low pressure

20 are connected to the low pressure ports 16 and 16'.

FIG. 6A shows a pressure state of the pressure oil in the drain channel 22, the port 25a for low pressure, the high pressure port 15, the port 25b for low pressure, the cancel port 20a', the low pressure port 16', the cancel port 20b', and the

25 drain channel 22 when taken along the cutting-plane line 6A-6A

in FIG. 5. FIG. 6B shows the pressure state of the pressure oil in the drain channel 22, the cancel port 20a, the low pressure port 16, the cancel port 20b, the port 25a' for low pressure, the high pressure port 15', the port 25b' for low pressure, and the

5 drain channel 22 when taken along the cutting plane line 6B-6B in FIG. 5.

As shown in FIG. 6A, by setting a width H of the high pressure port 15 and widths d of land portions from side edges of the high pressure port 15 to the ports 25a and 25b for low

10 pressure, a pressing force of the pressure oil of the high pressure port 15 which acts on the pintle 3 can be expressed as a function of a port area A1. Namely, it can be assumed that as for the pressure at the time of the pressure oil of the high pressure port 15 acting on the pintle 3, the pressure for the

15 width H is applied to the high pressure port 15 part as it is, and the pressure in the land portions is distributed while decreasing in a shape of a gradient of a hypotenuse of a right-angled triangle in the area from the high pressure part of the high pressure port to the low pressure parts of the ports 25a and 25b

20 for low pressure.

Consequently, if it is assumed that the area on which the pressure oil of the high pressure port acts is the port area A1, it is expressed by $A1 \doteqdot H + d / 2 + d / 2 = H + d$. The lengths in the circumferential direction of the high pressure ports 15

25 and 15' in the pintle are necessary as the port area, but if it is

assumed that the lengths in the circumferential direction of the high pressure ports 15 and 15' are fixed, the port area can be expressed as the function of the above-described relation in the width direction of the cutting-plane line A-A.

Similarly, a port area A2 in the cancel ports 20a, 20b, 20a' and 20b' can be expressed by A2 $\fallingdotseq$ (d / 2 + h + d / 2) + (d / 2 + h + d / 2) = 2h + 2d when it is assumed that the widths of the cancel ports 20a, 20b, 20a' and 20b' are h, the widths from the cancel ports 20a and 20b' to the drain channels 22 are d, the widths from the cancel ports 20a and 20b' to the low pressure ports 16 and 16' are d, and the widths from the cancel ports to the ports 25b and 25a' for low pressure are d.

The width d from the cancel ports to the drain channels, the width d from the cancel ports to the low pressure ports, and the width d to the ports for low pressure are all made equal. However, the width d1 from the cancel port to the low pressure port is formed to be equal at the left and the right, and the width from the cancel port to the drain channel and width d2 from the cancel port to the port for low pressure are formed to be equal, whereby the width d1 and the width d2 can be formed to differ from each other.

By making A1 = A2 as the port area, the radial force in the radial direction acting on the pintle 3 by the pressure oil of the high pressure ports 15 and 15' can be balanced by the cancel ports 20a, 20b, 20a' and 20b'. By using the ports 25a, 25b,

25a' and 25b' for low pressure having the same port area as the port area of the low pressure ports 16 and 16', the radial force acting on the pintle 3 by the low pressure ports 16 and 16' can be similarly balanced.

5   In addition, when a motor and an alternating type of pump are used as the radial type hydraulic machine, even if the high pressure port functions as the low pressure port by the rotating direction of the cylinder block, the cancel ports can be always opposed to the high pressure ports, and the ports for low

10   pressure can be always opposed to the low pressure ports, as a result of forming the ports 25a, 25b, 25a' and 25b' for low pressure.   In the embodiment shown in FIG. 1, the ports for low pressure into which the pressure oil of the low pressure port is introduced are not formed at the regions of the pintle to

15   which the low pressure port opposes, namely, at the regions of both side portions of the high pressure port, but the ports for low pressure can be formed.   The present invention in application is not limited to the above-described embodiment, but the present invention also includes the constitutions which

20   the person skilled in the art can properly apply thereto.